SCIENCE AND TECHNOLOGY

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A REPORT OF THE PRESIDENT

TRANSMITTED TO THE CONGRESS 1995

TO THE CONGRESS OF THE UNITED STATES

This Nation's future depends on strong public and private support for science and technology. My Administration's decision to make sound investments in science and technology even as the federal government cuts other spending is premised on three basic assumptions:

- Technology is the engine of economic growth.
- Scientific knowledge is the key to the future.
- Responsible government advances science and technology.

The Congress and the American people can find evidence of the Administration's dedication to responsible government support for science and technology in our defense and economic policies as well as our management of the science and technology enterprise. We have decreased the federal deficit, helped to create millions of new jobs, and improved the tax treatment of small businesses and of investments in research and development. Hemispheric and global trade agreements as well as relaxation of outdated export controls have opened huge export markets to America's high-tech industries. My *National Security Strategy of Engagement and Enlargement* (February 1995) depends on farsighted and efficient science and technology investments. Our foreign policy and security interests are also supported by mutually beneficial international cooperation in science and technology.

We have consistently endorsed technology policies to increase prosperity and enhance environmental quality. In *Technology for America's Economic Growth* (February 1993) and *Technology for a Sustainable Future* (July 1994) this Administration conveyed to the American people our plans for public/private partnerships to improve the business environment, enhance access to quality education and training, support development of information infrastructure, ensure continued excellence in health care, and strengthen America's global competitiveness.

Streamlined government based on strong partnerships — within the government, with the private sector, and among nations — is a hallmark of the Clinton/Gore Administration. The "virtual department" I created by establishing the National Science and Technology Council (NSTC) has cut bureaucratic red tape and produced a historic first: an integrated research and development budget that focuses on national goals. The NSTC has also produced large savings by enabling agencies to coordinate their efforts, divide tasks, and share resources.

My Committee of Advisors on Science and Technology (PCAST) provides critical links to industry and academia. Their oversight of NSTC activities, such as development of strategies for the management and disposition of fissile materials, promises to improve the federal effort. So, too, do the forums and workshops that have drawn in thousands of experts and stakeholders to help develop priorities in areas as diverse as fundamental science, environmental technology, and health, safety, and food research.

'This Nation's future depends on strong public and private support for science and technology.'

"Science and technology investments will prepare us for the challenges of the 21st Century."

I am also very proud of the steps we have taken to improve international cooperation in science and technology. Through the Gore-Chernomyrdin Commission we have used science and technology cooperation to ease the Russians' transition to democracy and a market economy. We have received valuable new technology and cultivated a crucial partner in global affairs through Russian participation in the international space station. We have used the Megasciences Forum of the Organization for Economic Cooperation and Development and other international forums to explore ways to share the increasing costs of cutting-edge research while maintaining our position of world leadership. Bilateral science and technology cooperation with other nations, including advanced industrial economies such as Japan, and big, emerging markets such as the People's Republic of China, serve us well in the global economy — giving us access to new ideas and new technologies while creating new opportunities for business.

Economists have estimated that the social rate of return on investments in research and development averages about 50 percent, or about double the average private rate of return. Clearly a solid federal investment program is justified even in the leanest times. It is especially important for the federal government to maintain its investments in science and technology when the pressures of international competition are leading businesses to focus on shorter term payoffs at the expense of more basic, longer term, and riskier research and development.

In *Science in the National Interest* (August 1994), the Vice President and I reaffirmed our longstanding commitment to world leadership in science, mathematics, and engineering. Scientific discoveries inspire and enrich us. Equally important, science and mathematics education provides all Americans with the knowledge and skills they need to prepare for and adapt to the high-technology jobs of the future and to exercise the responsibilities of citizenship.

This Administration has articulated clear goals and established priorities for federal spending, and our economic policies have improved the climate for private investment as well. We intend to work closely with Congress to ensure the wellbeing of our children and grandchildren. These investments will prepare us for the challenges of the 21st Century.

William J. Clinton

THE WHITE HOUSE

LETTER OF TRANSMITTAL

Mr. President:

The Office of Science and Technology Policy submits the 1995 Biennial Report in accordance with the provisions of the National Science and Technology Policy, Organization, and Priorities Act of 1976.

My colleagues in OSTP and I appreciate your strong support for U.S. science and technology.

Sincerely,

John H. Gibbons

John H. Gibbons
Director

SCIENCE AND TECHNOLOGY OUTLOOK AND REPORT

Scientific knowledge is the key to the future. Technology is the engine of economic growth. Together, science and technology build new businesses, provide good jobs, improve health and the quality of education, and protect us from threats as diverse as environmental degradation and military force. These essential tools of modern society open our eyes to new opportunities and challenges. For example, high technology industries, from computers to biotechnology, form the cutting edge of our economy, but their lead over tough global competition is narrow. Information technologies have transformed personal and business communication, offering immediate benefits but raising important long-term questions about access and control. The technological superiority of U.S. military forces helped bring about the collapse of the Soviet Union, an event that diminished the nuclear threat but left challenging regional instabilities in its wake. Our efforts to probe further into the universe and look more deeply into the smallest particles of matter instill national pride but often call for international cooperation in a world seemingly beset by competition and conflict.

'The federal government plays a crucial role in ensuring American leadership in science and technology.'

American mastery of science and technology will largely determine whether our citizens capture new opportunities — good jobs, a higher quality of life — and continue to enjoy basic amenities, including safe and affordable food and shelter. Innovations in myriad products and processes Americans count on for a better life, such as heart surgery, computing, and electric lighting, stem from scientific advances. The investments we make today in basic and applied research will assure the continuous flow of knowledge needed to develop new technologies for the future.

The federal government plays a crucial role in ensuring American leadership in science and technology. The Nation's world leadership in science, mathematics, and engineering derives from federal sponsorship. Federal research investments led directly to the technological leadership of U.S. firms in agriculture, aeronautics, semiconductors, computers, communications, pharmaceuticals, and scores of other critical areas.

Maintaining this leadership requires steady investment. The Administration proposes $73 billion for all research and development in Fiscal Year 1996, which would constitute about 40 percent of all U.S. research and development. The public will receive a substantial return on this investment. While there is much room for uncertainty in measuring the impact of federal research spending, repeated studies suggest that the payoff

TECHNOLOGY FOR AMERICA'S ECONOMIC GROWTH

The traditional federal role in technology development has been limited to support of basic science and mission oriented research and development. This strategy was appropriate for a previous generation but not for today's profound challenges. We must move in a new direction:

- strengthening America's industrial competitiveness and creating jobs;
- creating a business environment where technical innovation can flourish and where investment is attracted to new ideas;
- ensuring the coordinated management of technology all across the government;
- forging a closer working partnership among industry, federal and state governments, workers, and universities;
- redirecting the focus of our national efforts toward technologies crucial to today's businesses and a growing economy, such as information and communication, flexible manufacturing, and environmental technologies; and
- reaffirming our commitment to basic science, the foundation on which all technical progress is ultimately built.

(Source: *Technology for America's Economic Growth: A New Direction to Build Economic Strength*, February 1993)

to the Nation's economic welfare is great. The private rate of return on research and development spending — meaning the return to the firm performing the research and development — averages about 20 to 30 percent. But the social rate of return — including spillovers to other firms and customers — is about 50 percent, or twice as high.

The government's indispensable roles in advancing science and technology, include: 1) ensuring a strong base of fundamental science; 2) educating a scientifically and technically literate workforce; 3) providing a business environment that encourages innovation and investment; 4) investing in research and development that is critical to the economic and social needs of the nation, but cannot attract adequate private support; and 5) encouraging mutually beneficial international cooperation in science and technology. Science and technology confer benefits in areas outside the market, e.g., national security, public health, food safety, education and training, and the environment. Only federal research and development funding can ensure adequate attention to these key problems.

The federal government, acting for all Americans, can make long-term research investments where the returns are collectively essential to our country, but distant, individually uncertain, or difficult for private firms to secure. For example, many decades of public support for molecular biology, chemistry, and physics laid the foundation for today's pharmaceutical and biotechnology enterprises which now return billions of dollars to individual firms and provide many high paying jobs. As another example, our investments in space technology have led to our strong global position in the commercial launch and satellite business.

In 1993 this Administration began an intense reexamination of federal research and development priorities. This review of federal research and development management is an integral part of the Administration's commitment to make all of government more efficient and more responsive. The review continues, but we remain convinced that: 1) the Nation's future

depends on advances in science and technology; and 2) federal investment is an essential catalyst for such advances. We are determined to continue investments in the future despite fiscal pressures today. Progress toward the Nation's goals and the Administration's priorities has required significant changes in federal roles and responsibilities in the science and technology enterprise. Fiscal constraints have necessitated streamlining and some painful reductions in programs. Substantial improvements in management and the redirection of scarce resources still leave us with much to accomplish.

This report describes the actions and plans of the Clinton Administration to harness the power of science and technology. It examines the rationale for federal support of science and technology. It describes our strategy for using science and technology to meet the challenges that lie ahead, including several new research and development initiatives and public/private partnerships. Finally, the report explains the Administration's progress toward reorganizing the federal science and technology enterprise.

SCIENCE IN THE NATIONAL INTEREST

Science provides an endless frontier of inquiry. Advancing that frontier feeds our sense of adventure and our passion for discovery. The unfolding secrets of nature provide new knowledge to address crucial challenges, often in unpredictable ways. These include improving human health, creating breakthrough technologies that lead to new industries and high quality jobs, meeting our national security needs, protecting and restoring the global environment, and feeding and providing energy for a growing population. Science is a critical investment in the national interest, and we have pledged to:

- maintain leadership across the frontiers of scientific knowledge;
- enhance connections between fundamental research and national goals, such as economic prosperity, national security, health, and environmental responsibility;
- stimulate partnerships that promote investments in fundamental science and engineering and effective use of physical, human, and financial resources;
- produce the finest scientists and engineers for the twenty-first century; and
- raise scientific and technological literacy of all Americans.

(Source: *Science in the National Interest*, August 1994)

National Goals for Science and Technology

Thoughtful investments in science and technology fuel economic growth, strengthen national security, and improve the quality of life. This Administration has directed its efforts toward high priority areas, including:

- Economic growth and job creation
- Education and training
- Environmental quality
- Health
- Information technology
- National security
- World leadership and cooperation in science, mathematics and engineering

EL NIÑO FORECASTING REDUCES AGRICULTURAL LOSSES

Early forecasts of the dramatic shifts every few years in the timing and intensity of precipitation patterns associated with El Niño have enabled farmers in several South American countries to prevent crop losses of hundreds of millions of dollars, keeping food available and prices from rising sharply. This improved forecasting capability was developed over the past ten years with research into the causes of El Niño by the United States and other countries through the International Tropical Ocean-Global Atmospheric Program.

Adverse and fluctuating weather events on a large scale cause billions of dollars in crop losses and other economic impacts each year. Drought in the Sahara, delayed monsoons in India, and prolonged dry periods in food-growing and water resource regions create food and water shortages for large populations. Even in developed countries such as the United States, events such as the Great Plains droughts of 1988, the Mississippi River floods of 1993, and the California floods of 1995 cost millions of dollars in damages and crop losses.

El Niño affects weather from Australia to South and Central America, as well as into the western and southern United States. Although fluctuations in the weather cannot be prevented, the ability to predict extreme changes months in advance allows for agricultural yields to be protected by changing crops and planting schedules. Our improved forecasting ability is sufficiently accurate to also be applied to water resource planning in the southwestern United States. Water supplies can be protected by adjusting storage and management practices.

Success in each area will depend on advances in fundamental science, continuing technological innovations, and responsible governance.

Scientific knowledge is the key to the future. America's future demands an expanding knowledge base, which requires investment in our people, institutions, and ideas and sharing broadly with our global partners. Science lies at the heart of that investment — it is an endless and sustainable resource with extraordinary dividends. The nation's commitment to world leadership in science, engineering, and mathematics created the world's leading scientific enterprise, whether measured in terms of discoveries, citations, awards and prizes, advanced education, or contributions to industrial and informational innovation. Our scientific strength is a treasure we must sustain and build on for the future.

The United States has refined a system for selecting excellence in ideas, individuals, and institutions that is extremely competitive and productive. The system cannot always pinpoint the exact areas or nature of scientific breakthroughs or the timeline to fundamental discoveries. Over decades, however, it reliably produces discoveries that enrich the lives and prospects of our citizens and, when transformed to practical, cost-effective products, reorganize old businesses and create new ones. For example:

- *Fiber optics* was a germ of an idea in an obscure area of basic physics in 1966 but now carry most U.S. long-distance telecommunications.
- *The Global Positioning System* represents a confluence of basic research in physics, software, communications, and high-speed electronics. First developed for military purposes, it is now rapidly expanding into commercial markets for navigation and air safety and monitoring Earth's large scale ecosystems.

- *Severe weather prediction* emerged from the integration of space platforms, immense computing power, and continued atmospheric science research to help prevent loss of life and property.
- *The repaired Hubble Space Telescope* opened our eyes to distant galaxies in the same way the early space program opened our eyes to the wonders of our fragile planet and solar system. At a fundamental level, the discoveries it enabled have led to a restructuring of our thoughts about the evolution of the universe.

"At least a quarter of recent U.S. economic growth came from new technology."

Technology is the engine of economic growth. Over the past 50 years, at least a quarter of U.S. economic growth — possibly as much as half — came from new technology built upon earlier fundamental discoveries. These advances created millions of good new jobs, a cleaner environment, better health and longer lives, new opportunities for individuals, and enrichment of our lives in ways we could not imagine half a century ago.

Traditional factors such as access to natural resources and cheap labor no longer determine international competitiveness. Instead, the new growth industries are knowledge based. They depend on the continuous generation of new technological innovations and the rapid transformation of these new technologies into commercial products the world wants to buy. This requires a talented and adaptive work force capable of using the latest technologies and reaching ever-higher levels of productivity.

We can only make educated guesses about which investments will catalyze revolutionary developments, and we must expect some failures. But if the past is any predictor, our expectations for an excellent return on our investments are not misplaced. For instance:

- Early investments in ARPANet, the first national computer network, have brought us to the 25th anniversary of the Internet, a prototype of the Global Information Infrastructure. When it started out, ARPANet could transmit only 56,000 bits of data per second. Today networks using technology several generations more advanced routinely transmit 45 million bits a second — almost a thousand times faster. The federal government provided a relatively small catalyst (a few tens of millions of dollars annually) that has been matched several times over by private-sector investment in the Internet. Today dozens of companies are investing millions of dollars and competing to provide Internet connections and new services to the tens of millions of Internet users around the world.
- Public investments in biomedical research spawned a multi-faceted biotechnology industry that already accounts for 100,000 jobs and $8 billion in annual sales. We owe extraordinary advances in agriculture and in chemical and pharmaceuticals processing, as well as our ability to capture large markets in health care and other industries, to fundamental research in molecular biology and development of advanced instrumentation funded by the U.S. government.

TECHNOLOGY FOR A SUSTAINABLE FUTURE

A carefully crafted, forward-looking environmental technology strategy, along with a strong societal commitment to environmental protection, will allow us to move expeditiously toward sustainable development. An environmental technology strategy should:

- assure that the federal regulatory and policy-making apparatus is directed toward facilitating the development of prevention and monitoring technologies critical to achieving sustainable development over the long term and balanced with control and remediation technologies in the near term;
- increase the resource efficiencies of our technological infrastructure by adopting a systems approach that employs the tenets of industrial ecology;
- forge public-private and federal-state partnerships directed to advancing the development, commercialization, and diffusion of environmental technologies;
- shorten the cycle time from research and development to commercialization and export of environmental technologies; and
- promote the use of environmentally sound and socially appropriate technologies in developing nations throughout the world.

(Source: *Technology for a Sustainable Future,* July 1994)

Our vision is of long-term economic growth that creates jobs while improving and sustaining the environment. Reconciling these goals requires an environmental technology strategy that helps industry shift from waste management to pollution prevention and efficient resource use. Nationally, it will create economic growth by capturing the rapidly growing market for clean technologies. Globally, it will help developing countries leap frog directly into sustainable technologies in many industrial and service sectors.

Responsible government advances science and technology. Government is an essential actor in making sure science and technology help the Nation reach its goals. Only the federal government can bring the benefits of science and technology to nonmarket areas, such as national defense, education and training, environmental quality, global health threats, or world-class fundamental scientific research. In these areas, a strong government presence is crucial.

A government role is also vital in promoting, in partnership with the private sector, those technologies critical to economic growth and to the creation of good jobs that cannot attract sufficient private investment. We invest government funds, on a cost-shared basis, where private sector investment is not adequate to the job because of unacceptably high technical risks, prohibitive cost, long payback horizons, or where the returns cannot be captured by the investing firm but spill out to competitors, other firms, or society at large. The social rate of return to research and development investments, where the benefits may accrue to several firms and to consumers in the form of less costly and higher quality products, is about twice as high as the average rate of return to private investment.

A regulatory and economic environment favorable to capital formation and private-sector investment in research and development is also essential to advances in science and technology. To encourage private investment, the Administration supported and Congress extended the research and experimentation tax credit in 1993 for 3 years and reduced capital gains taxes for

small businesses. To encourage the formation of alliances for new technology development, the Administration reduced antitrust barriers to the formation of joint production ventures. To promote private investment in the national information infrastructure, the Administration transferred to the private sector a portion of the radio frequency spectrum previously used by federal agencies and allowed competitive bidding in granting new licenses.

After careful review of the impact on national security and foreign policy interests, the Administration liberalized controls on the export of computers, telecommunications, and other technologically sophisticated equipment. This action allowed U.S. industry access to foreign markets that some have estimated are as large as $30 billion over the next few years without compromising our security.

Bilateral and multilateral trade agreements have expanded access to foreign markets for America's high-tech companies. For example, under NAFTA, Mexican tariffs have been eliminated on 70 percent of U.S. exports in the computer equipment and software sector. The agreement negotiated at the Uruguay Round of the General Agreement on Tariffs and Trade provides for unprecedented international agreement on patents, copyrights, trademarks, trade secrets, and other intellectual property issues. These directly affect the competitiveness of U.S. high technology companies.

"The public sector has a vital partnership role to play in the science and technology enterprise."

Inextricable Links

Science and technology are linked in a multitude of ways, each building constantly on the gains in the other domain. It is certainly true that technological advance ultimately depends on fundamental science, and the highly trained people educated at our universities and colleges. But old distinctions between "basic" and "applied" science are blurring.

In a world of ever tougher global economic competition, links between public and private science and technology initiatives must grow stronger as well. Private businesses are the principal actors in converting technology to goods and services, to profits and jobs, and they have supported much of the research and development needed to develop new technologies. But the public sector has a vital partnership role to play in the science and technology enterprise.

Symbiosis between science and technology. The relationship between basic research, applied research, technology development, and commercialization is not a linear progression. Rather, disparate fields of research (e.g., physics and biology), stages of research (e.g., benchtop and field test), and venues of research (corporate and government, domestic and international) now flourish symbiotically. Often a technical or engineering advance will stimulate or enable scientific inquiry. For example, cars powered by internal combustion engines hit the road long before scientists began to understand, even imperfectly, some fundamental principles of combustion. Magnetic resonance imaging was founded on basic research in atomic and nuclear physics—but it could not have been put to practical use in medical diagnos-

"Basic science, applied science, and technology are profoundly interdependent."

tics without the separate but parallel development of a number of sophisticated technologies, especially the microprocessor, the "computer-on-a-chip" that could be built directly into the instrument. The cancer treatment drug taxol is derived from the yew tree of the Pacific Northwest, and without the research to classify and study the natural plants and animals it might never have been found. Most of today's experimental science has been enormously enhanced by state-of-the-art technology.

The search for something practical often forces a new look at the scientific principles that underlie new phenomena; the prepared mind is ready to take a leap into the practical application. The transistor was invented in a lab program to develop better switches — but the scientific work of previous decades on solid state physics and quantum mechanics was absolutely essential to this invention.

The blending of discovery and application is repeated across virtually all science and engineering — from biomedicine to environment to space exploration and aeronautics to materials and manufacturing. Basic research on materials results in stronger, long lasting roads and bridges and lighter, but safer airplanes and cars. Today's wonder drugs and tomorrow's bioremediation of chemical wastes are direct products of our continuing investments in biology, chemistry, physics, mathematics, and earth science.

The fundamental point is that basic science, applied science, and technology, though different in approach, motivation, and scale, are profoundly interdependent.

Public and private partnership. The accelerating pace of technological advance, ever shorter product cycles, and rapid worldwide diffusion of technologies mean that many companies are finding investment in risky or lower yield research and development less attractive than in the past. This means that government research and development partnerships with industry in growth-enhancing technologies are more important than ever. Without government to share the risk at the pre-commercial stage, individual companies are reluctant to take the plunge, especially when a substantial fraction of the total return may not be captured by the individual investing company.

The problem of capturing private returns on pre-commercial research and development investments is especially great in widely dispersed and fragmented industries such as agriculture or building and construction. If government fails to support technology advances in these industries, at least on a cost-shared basis, it will not get done . . . or it will be done by international competitors. Government support of research and development is an American tradition. For example, the Morrill Act of 1862, which founded the land grant colleges across the nation, was aimed at nurturing agriculture and the mechanical arts and helped build some of our top research universities.

In general, where there is technological uncertainty, research and development projects with a strong combination of potential public and commercial benefits merit a mix of government, academic, and industry support. For

example, education and training technologies that challenge and reward our children and bring lifelong learning within reach of everyone have multiple public and private benefits: a better educated citizenry, a world-class work force, opportunities for people to retrain themselves in response to changing technologies and jobs, and a rich commercial market for the learning technologies. Government's role in facilitating the National Information Infrastructure and the emerging Global Information Infrastructure is not only to share the costs of research and development, but also to assure access to all Americans and compatibility with other nations' information highways.

Today many in industry are taking a new, results-oriented view of their research and development programs. Corporate cost-cutting drives have led to focusing in-house research and development on technologies that are close to commercialization, at the expense of more basic, longer term, or riskier research. The new model of best practice that is taking form is to create partnerships for riskier, generic, pre-commercial research and development—teaming with other companies, with universities, and with the government.

The Administration has re-invented government partnership programs to make sure that they are:

- market-driven, with industry leading the joint research agenda;
- cost-shared, with the private sector putting up half or more of the money, as a quasi-market test to make sure the technological risk is worth taking;
- competitive, merit-based, and peer-reviewed; and
- evaluated periodically and rigorously to make sure that the projects have the intended effect.

PARTNERSHIP PROGRAMS: LINKING HIGH-TECH INDUSTRY AND GOVERNMENT

Advanced Technology Program (ATP). The National Institute for Standards and Technology's ATP works with industry to promote the development of high risk but highly promising technologies to enable novel or greatly improved products and services for the world market. Government provides the catalyst, but industry conceives, partially funds, and executes ATP projects. On average, ATP award recipients pay more than half the total costs of the research and development, and all awards are made through a competitive merit-based selection process. Cost sharing helps ensure that companies have a vested interest in the success of the project and timely commercialization, and competitive selection guards against political interference.

Technology Reinvestment Project (TRP). This Nation cannot maintain separate military and civilian industrial bases and keep the technological advantage that has been the mainstay of our defense. The dual use technology strategy is a fundamentally new way of doing business designed to break down barriers created over decades between defense and commercial sectors. The TRP, a multiagency effort, is the largest and most visible dual use initiative. The TRP has completed 2 major competitions in which federal matching funds totaling $805 million were awarded to 251 projects involving 1,900 firms, universities, and others, leveraging a total of $2 billion.

Cooperative Research and Development Agreements (CRADAs). CRADAs are cost-shared projects between industry and government laboratories. The federal labs contribute expertise and technology but do not provide funds to the non-federal party. By the end of 1994, agencies had a total of more than 5,000 CRADAs valued at over $3.8 billion.

"Federal investments in science and technology have direct impacts on quality of life."

With the assistance of progressive government policies, U.S. companies have recently regained a competitive edge in critical technologies, such as semiconductors, once thought lost to Japanese and other competitors. We must guard against a scenario in which American scientists and inventors make breakthroughs, only to see the jobs and profits growing out of U.S. discoveries and inventions flow to overseas competitors.

Federal Priorities in Science and Technology

Effective governance requires transforming our broad goal — enhancing the general welfare with advances in science and technology — into concrete, manageable objectives. We have focused federal efforts in priority areas that envelop what America values most. These priorities were established under the auspices of the National Science and Technology Council.

The following text describes federal investments in these areas, highlighting a small cross-section of our research and development programs. These research and development initiatives generally serve more than one objective—a salutary effect of the effort to stretch taxpayer dollars and optimize each investment in the future. Many of our efforts, for example, in environment, health, and basic research benefit from international cooperation while advancing our interests in international stability and economic progress.

Health. Good health and long life are goals of every American. A strong biomedical research base, an accessible, efficient health care system, and a safe and affordable food supply are prerequisites to these goals. Federal investments in these areas have direct and immediate impacts on quality of life, and they make good economic sense as well. For example, each year vaccinations of infants to prevent *haemophilus influenzae* type b saves our nation approximately 20 times the total cost of the research leading to the vaccine's development.

We have witnessed vast improvements in health and longevity in recent decades, but enormous challenges still exist. For example:

- Cardiovascular disease remains the leading cause of death and disability in American men and women;
- Alzheimer's disease afflicts 4 million Americans at an annual economic cost of $90 billion and untold social cost;
- Each year foodborne disease leads to as many as 33 million illnesses and $13 billion in medical costs and productivity losses;
- Injuries, many preventable, cost society $220 billion annually;
- AIDS has become the leading cause of death among all Americans ages 25-44;
- Breast cancer is diagnosed in 190,000 women each year and is the cause of 46,000 deaths annually.

To address the range of problems these examples represent, the Administration has established scientific goals and research priorities in 5 main areas. *Biomedical, socio-cultural, and behavioral research and development* will reveal

the fundamental processes of human biology and provide insight into risk factors for disease and injury. *Health systems and services research and development* will improve access to the benefits of one of the world's most sophisticated health systems. This type of research recently led to two clinical practice guidelines — one on low back pain and one on fluid in the inner ear of children — that could reduce health care expenditures by more than $5 billion. *Health promotion and disease and injury prevention research and development* offer the most direct means to reduce the enormous personal, social, and economic toll from premature birth, childhood illness, cancer, obesity, heart disease, disabilities, infectious disease, drug abuse, and tobacco use. *Food safety, security, and production research and development* will ensure we meet the food needs of the United States and the world in the year 2100. We intend to harness the genetic resources of plants and animals and combine that potential with improved food safety technologies. *Human nutrition research and development* will help us reduce the risk of diet-related disease — the largest controllable factor in long-term health for Americans who do not smoke, drink to excess, or work in hazardous environs.

Health, safety, and food are global concerns, and research and development in these areas has significant international dimensions. For example, bilateral and multilateral research programs are providing international research experience to the next generation of health and agriculture scientists during the early stages of their careers. International data standards are being developed to facilitate future international collaborative research efforts, particularly comparative studies in epidemiology and health systems and services. Emerging infectious disease threats are a reminder that no nation can be complacent regarding human vulnerability to microorganisms, and emphasize the continued need for collaborative surveillance systems and research on disease prevention and treatment. Such collaborative programs encourage continued cooperation and mutually beneficial partnerships between the United States and other countries.

NEW ADVANCE IN TREATING SICKLE CELL DISEASE

Sickle cell disease (SCD) affects 1 in 500 African Americans. Painful crisis, the most common manifestation of SCD, impairs the quality of life and productivity of affected individuals and frequently requires emergency room treatment or hospitalization. Sickle cell patients often require chronic transfusion therapy, which puts them at risk for disease transmission and other problems.

NIH has completed a clinical trial of the drug hydroxyurea, the first therapeutic agent for patients with SCD to show promise of clinical efficacy without life-threatening toxicity. The trial was deemed successful when interim analysis of data indicated that daily administration of hydroxyurea reduced the frequency of painful episodes and associated hospital admissions by about 50 percent. Hydroxyurea therapy also reduced by half the frequency of acute chest syndrome, a life-threatening complication of SCD. Patients receiving hydroxyurea required 50 percent fewer units of transfused blood than patients who took a placebo, a finding with important public health implications. The results of this trial are expected to improve the quality of life for SCD patients and reduce the costs associated with their care.

LONG TERM ECOLOGICAL RESEARCH AND THE HANTAVIRUS

Mice and other rodents are important, often abundant inhabitants of arid environments. They are a food source for predators and directly affect plant communities by consuming and spreading plant seeds. Thus, rodents have been studied by scientists at the Sevilleta Long Term Ecological Research (LTER) site since it was established in 1988 as part of a research program to understand the dynamic processes that shape and change ecosystems.

In 1993 the rodent research took on a new importance when physicians in northern New Mexico and Arizona reported a high number of deaths from an unusual respiratory disease caused by a previously-unknown species of Hantavirus. Hantaviruses were known to be transmitted by rodents, and anecdotal information from residents in the afflicted area suggested that rodents were exceptionally abundant in the winter of 1992-93. This led health officials to speculate that, if true, the increased potential for human contact with rodents might have led to the sudden epidemic.

The Federal Centers for Disease Control and Prevention (CDC) in Atlanta enlisted Sevilleta LTER scientists to provide ecological information on the deer mouse and other native rodent species. The LTER database showed a ten-fold population increase in various field mouse and wood rat populations during the spring of 1993, thus confirming the likely connection between the Hantavirus epidemic and rodent population increases. The ecological and climatological data from the LTER research will be important in formulating models that predict future rodent population increase and allow improved disease prevention strategies. Thus, research initially conducted to understand the role of rodents in natural habitats is playing a key role in safeguarding human health.

Environmental Quality. A fundamental challenge facing our society is sustainable development: development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Protecting our environment and natural resource base while enhancing economic growth requires knowledge of many complex natural phenomena, their interrelationships, and the effects of human activities. We are developing a research program that will provide this knowledge and enable us to anticipate future environmental problems and prevent them, rather than respond to them after the fact. The benefits of such an approach are a cleaner environment at lower cost, an increase in U.S. economic competitiveness, and improved quality of life for all Americans.

The range of environmental and natural resource issues related to sustainable development is diverse: it encompasses both urban and rural issues at the local, regional, and global scales, affecting human health and the quality of both aquatic and terrestrial ecological systems. These issues include pesticides, toxic substances, hazardous and solid waste, water quality, air pollution, and natural disasters. Other important local-to-regional concerns include improving resource use by addressing such problems as inadequate water supplies, the loss of wetlands, soil erosion, and the extraction and use of energy resources. Other critical problems have international and global implications: deforestation, loss of biological diversity, stratospheric ozone depletion, and climate change.

We have made significant progress in learning how to manage our environment and natural resources effectively and to repair damage from past practices, largely because of our improved

understanding of complex natural systems. Yet with our growing knowledge has come recognition of our vast ignorance about many facets of environmental issues and the need to develop the information and data to manage and avert future threats more effectively and efficiently. No longer can we repeat the mistakes of the past that now pose huge burdens on our society and require amelioration.

Faced with inadequate information, we often either fail to capture opportunities to avoid significant problems with reasonable solutions or overcompensate with overly strict controls and limits, wasting resources on the wrong problems or responses. In contrast, balanced and informed public policy must be based upon a sound understanding of problems and potential solutions; this is an important role of federal scientific research. Scientific research should provide unbiased knowledge relevant to critical policy questions. Effective decisions regarding the environment and natural resources must be informed by integrated knowledge from the natural, social, and economic sciences.

SCIENTIFIC RESEARCH PROTECTS HUMAN HEALTH

Twenty years ago we determined a need to understand the impacts of emissions of synthetic chemicals containing chlorine, bromine, and fluorine on stratospheric ozone. Today we know unequivocally that the ozone layer is being depleted because of human activities and that loss of the ozone layer threatens human health by increasing the ground-level UV-B radiation that causes skin cancers. This knowledge has led to international agreements that limit the production and use of ozone-depleting chemicals, and advances in technology have resulted in industrial and manufacturing use of cost-effective substitutes that do not degrade the ozone layer. Because of the research and early detection of stratospheric ozone depletion, technological response has enabled us to largely avert a major global environmental problem while still providing the benefits of air conditioning, refrigeration, and other necessities and amenities that once depended on ozone-destroying chemicals.

An improved understanding of the environment will contribute to a healthier, safer America, enhanced national security, and a stronger economy. Environmental research and development contributes to public health and well being by increasing our understanding of the changes in environmental conditions that can threaten health and safety. We know that changes in climate can increase the loss of life from heat-related mortality and severe storms and increase the range of diseases such as malaria, dengue fever, and cholera. Increases in urban and rural ozone and airborne particles can increase the incidence of respiratory ailments such as asthma, and exposure to toxic materials can lead to cancer, birth defects, and other health problems. Further research is needed to address and prevent environmentally-related health problems.

Environmental research and development contributes to our national security by improving management of ecosystems and natural resources. We have witnessed instances of environmental degradation, ecological damage, and depletion of natural resources creating confrontations between nations. Predicting, preventing, and/or remediating potentially destabilizing environ-

TIMELY HURRICANE WARNINGS SAVE LIVES, PROPERTY

Improvements in the science and technology of weather observation and analysis time have significantly decreased the number of hurricane-related deaths, particularly since the middle of this century. The combination of meteorological research, supercomputers, satellite observations, sophisticated image processing, and vastly improved communications technology has enhanced our early warning capability along with the accuracy of our daily forecasts.

Hurricane Andrew in 1992, for example, was tracked from the moment it came off the coast of Africa. Recognition of the storm's increasing strength resulted in a hurricane warning for the south Florida coast at 8 a.m. Sunday, August 23. Andrew struck Dade County, Florida, at 3:49 a.m. Monday. During the warning, radio and television stations devoted air time to tracking the storm, relaying official bulletins, discussing its potential severity, and providing guidance on preparation and evacuation.

The majority of Dade County residents reported that they had sufficient warning to prepare for the storm and that television had been their principal source of information. Early warning allowed almost 750,000 people to evacuate the area. The impact of the hurricane was catastrophic, estimated at $30 billion in property damage. Remarkably, however, only 15 deaths were directly attributed to Andrew, despite the huge number of people at risk.

mental problems, coupled with the development of long-term sources of food, water, and energy, are essential to global stability and U.S. national security.

Environmental technologies are the bridge to a stronger economy and sustainable future. We are working with industry to: (1) develop more cost-effective remediation technologies, thus decreasing current cleanup costs at government and industrial facilities; (2) decrease future cleanup costs by emphasizing pollution avoidance; and (3) reduce market and government inefficiencies that prevent the diffusion of environmental technologies. Federal environmental technology programs are improving U.S. economic competitiveness in a growing international market, while providing for more effective environmental protection and more efficient resource use. These investments will help U.S. industry capture a larger share of the annual global market for environmental technologies, currently estimated at about $300 billion, and predicted to grow to over $400 billion by 1997. The payoff will show up in a cleaner environment and in high-wage jobs; for every $1 billion in exports, it is estimated that 17,000 new jobs will be created.

The Administration's comprehensive strategy for environmental research and development is focused on 7 main issues: air quality; biodiversity and ecosystem dynamics; global change; natural disasters; resource use and management; toxic substances and hazardous waste; and water resources. In each area, we are supporting research to help answer the following policy-relevant questions:

- What are the natural phenomena and human activities that cause environmental change?
- When, where, and by how much and at what rates will the environment change as a result of human activities?
- How will natural and human systems be affected by environmental change, including extreme events?

- What are the present and prospective technical options and policy responses for mitigation and restoration of, and adaptation to, environmental changes?
- What are the institutional and economic barriers to implementing available options, and what are the costs and benefits of implementation?

In addition to broad support for these main issues in the environment and natural resources, our strategy identifies five high-priority research areas that cut across existing efforts and require increased emphasis. Important gaps exist in our understanding of the natural environment, the impacts of human activities on the environment, and the influences of environmental change on human (both biological and social) and ecological systems. To address these questions, increased near-term efforts are needed in the following areas:

- *Ecosystem research,* to promote the efficient use of natural resources while sustaining ecosystem integrity for future generations.
- *Observations and data management,* to ensure that the necessary measurements are made efficiently and that the data are widely available to all stakeholders in easily usable forms.
- *Socioeconomic dimensions of environmental change,* so that we understand the underlying human influences on the environment and the potential responses of society to change.
- *Environmental technology,* to protect the environment, while stimulating economic growth and capturing emerging global markets.
- *Science policy tools,* to provide the tools (e.g., integrated assessment and risk models) required by policymakers for informed decisions on complex environmental/societal issues.

Economic growth and job creation. Our Nation faces significant economic challenges. Markets are global, competition is fierce, technological change is swift and unabating. Meeting these challenges requires a strategy to equip American companies and workers to compete successfully in the 21st century economy.

Technology policy is a linchpin in this strategy. A full partnership between government and the private sector is needed to enhance the role that technology plays in promoting competitiveness, creating high-wage jobs, and fostering sustainable development. Sometimes this requires that government get out of the way — by reducing unnecessary export controls and reinventing more effective, less burdensome regulation. And sometimes the government must partner with industry to help build the nation's 21st century technological infrastructure and to advance high-risk, high-payoff technologies that are the foundation for future prosperity.

Several elements are involved: continuing our historic commitment to support of basic science, which is the ultimate foundation for all technological advance; creating a climate that fosters private sector innovation and commercialization; supporting industry-led technology development partnerships; facilitating the deployment of technology; leveraging commercial and

'Technology policy is a linchpin in our stragegy.'

'Government must partner with industry to build technological infrastructure.'

dual-use technologies to meet defense needs; and promoting the infrastructure that supports the private economy — including the nation's traditional transportation system and the new information superhighway.

Creating a climate that fosters private sector innovation and commercialization. Our national technology policy must address the broad range of factors that affect U.S. companies' ability to develop technology, turn innovations into products and services, and bring them to global markets. Continued emphasis on debt reduction is a must, to free up capital for private sector investment in research and development, plant and equipment, and new or expanding businesses. Other issues include tax policies that encourage innovation, including extension of the research and experimentation tax credit; reform of regulatory barriers to innovation, while safeguarding the environmental and health goals that are the object of regulation; reducing outdated Cold War export controls; and strengthening intellectual property protection.

Support for industry-led technology development partnerships. Programs such as the Advanced Technology Program and the Technology Reinvestment Project are a small part — less than 2 percent — of the total federal research and development investment. But these programs are a crucial link between the $73 billion federally funded science and technology base and industry's own investments (estimated at $107 billion for 1995) to take technology to the market place. These programs support longer term, riskier, and infrastructural technologies, not product development. Awards are made on the basis of rigorous competitive processes — not political decisions. And industry contributes at least half the costs of the projects, thus ensuring that they are driven by market needs.

In addition to these programs, the government is partnering with industry in a variety of industry-led research and development initiatives, including microelectronics, electronics manufacturing, aeronautics, and biotechnology. Many of these initiatives combine goals of competitiveness, economic growth, and job creation with public benefits of environmental protection, improved health and safety, and less dependence on foreign sources of energy. The Partnership for a New Generation of Vehicles and the Building and Construction initiatives are examples.

Facilitating the rapid deployment of civilian technologies. Stimulating the development of innovative technologies is only part of the equation. Another essential part is to make sure that all U.S. industry, including the small and medium sized firms that are the foundation of American manufacturing, get access to efficient, up-to-date production methods. The Manufacturing Extension Partnership operated by NIST in the Department of Commerce is a grassroots effort to improve the competitiveness of the nation's 370,000 smaller manufacturers. Currently, the network includes 44 centers; the goal is to create a national network of 100 centers able to meet the needs of America's smaller manufacturers.

Building a 21st century infrastructure. Development of the National Information Infrastructure (NII) and the emerging Global Information

Infrastructure (GII) is a top priority. These initiatives will promote a stronger economy, more competitive businesses, more efficient government, better education, and technological leadership. Discussion of private sector efforts to construct the NII and GII, and the government's role as a catalyst for development, are described below, in the section on Information Technologies.

Also of prime importance to economic growth in the next century are continued investments in more traditional infrastructure. For example, throughout most of this century, NIST's laboratory research program has provided essential support for virtually every industrial sector, in such areas as measurement methods and technologies, standards, data evaluation, and testing and quality assurance techniques. Investments in these "infratechnologies" will be even more vital to the Information Age of the 21st century.

A renewed, efficient transportation system is also essential. Our highway, air, and rail systems have given Americans the benefits of flexibility, low cost, and personal freedom, but they are in urgent need of renewal. A coordinated public and private research and development effort should meet these objectives for our future transportation needs:

- Physical infrastructure: Carry out research on materials, design methods, non-destructive testing techniques, and other technologies for low-cost, long-lasting highways, bridges, airports, and other structures. Develop low-cost methods for non-destructive testing and repair of existing structures.
- Information infrastructure for transportation: Apply the innovations available from the National Information Infrastructure to develop an

THE BUILDING AND CONSTRUCTION INITIATIVE

Construction is one of the nation's largest industries, with employment of 6 million and a total yearly value of close to $800 billion, yet U.S. building technology lags behind that of foreign countries and the incidence of injury in construction work is among the highest of all industries.

The federal government's goal is to develop better construction technologies to improve the competitive performance of the U.S. industry, raise the life cycle performance of buildings, and protect public safety and the environment. The initiative responds to a high level of industry interest and combines government and industry goals. We will work with industry to achieve by 2003:

- *Better constructed facilities*, meaning: a 50 percent reduction in delivery time; a 50 percent reduction in operation, maintenance, and energy costs; a 30 percent improvement in productivity and comfort; 50 percent fewer occupant-related injuries and illnesses; 50 percent less waste and pollution; and 50 percent more durability and flexibility.
- *Improved health and safety of construction workers*, meaning a 50 percent reduction in construction work injuries and illnesses.

Seven areas of research have been identified as important contributors to achieving the goals: information and decision technologies; automation of design, construction, and operation; high performance materials, components, and systems; environmental quality; risk reduction technologies; performance standards systems; and human factors. This initiative is dedicated to removing barriers to innovation, as well as putting greater emphasis on research and development and aligning government programs appropriately with industry needs.

THE PARTNERSHIP FOR A NEW GENERATION OF VEHICLES (PNGV)

This initiative is one of the federal government's premiere ventures into cooperative civilian technology development. In it, we are tackling a technological challenge as tough as putting a man on the moon — that is, to develop within 10 years a car with 3 times the efficiency of today's automobiles with no sacrifice in cost, comfort, or safety. If the project succeeds, the payoff to the public will be huge in terms of less dependence on foreign oil and lower emissions of greenhouse gases. The project also holds the promise of an extremely attractive car for world markets in the 21st century and a thriving U.S. auto industry to produce them. The government (in this case, a consortium of 7 federal agencies) and industry (the Big 3 automakers — Ford, GM, and Chrysler — and many suppliers of materials and equipment) are working closely on a cost-shared basis to break highly challenging technological bottlenecks where the benefits are as much societal as commercial. PNGV's research priorities are:

- development of advanced manufacturing techniques that make it easier to get new automobiles and auto components into the marketplace quickly;
- use of new technologies for near-term improvements in auto efficiency, safety, and emissions; and
- research leading to production prototypes of vehicles, including exploration in such advanced technologies as fuel cells, ultracapacitors, and hybrid vehicle propulsion systems.

Over the life of this partnership, funding will be shared roughly equally between government and industry, with the government contributing a greater share to basic research and to technologically riskier projects, and industry putting up a greater share as practical results get closer.

intelligent transportation system that will ensure safe and efficient intermodal operation of the nation's various transportation systems.

- Next-generation transportation vehicles: This includes research and development for improved materials, components, and design of energy-efficient, environmentally friendly heavy vehicles (trucks and buses), as well as the Partnership for a New Generation of Vehicles for autos. It encompasses continued world leadership in aircraft, avionics, and air traffic control systems, as well as a stronger U.S. space launch capability (described below). It also includes research and development to restore the U.S. as a world leader in innovative rail vehicle design and construction.

Education and training. The most important measure of success of this Administration will be its ability to make improvements in the lives of Americans. Few enterprises touch the lives of as many people as do those concerned with education and training. High-quality education and training benefit the individual whose knowledge and skills are upgraded, the business seeking a competitive edge, and the Nation in increasing overall productivity and competitiveness in the global marketplace. It is essential that all Americans have access to the education and training they need and that the teaching and learning enterprise itself becomes a high-performance activity.

The Administration has developed a research and development initiative aimed at using the power of modern information technology to achieve the Administration's lifelong learning goals — specifically the Goals 2000 and School-to-Work programs. We believe computer and multi-media technolo-

gy will make individualized, learner-centered, exploratory learning possible at affordable prices. And by using communication systems to connect homes, schools, and workplaces, we enhance the potential for learning outside of school. Current opportunities include:

- Instruction directly tailored to the learning level, ability, and style of every individual who receives it;
- Job performance aids that deliver "just-in-time" and "just-enough" training for workers who must operate and maintain workplace devices of all sorts;
- Universal human interfaces using speech, tactile responses, and eye movements to provide full access to the information infrastructure for our citizens with disabilities;
- Virtual laboratories using simulated advanced equipment (such as mass spectrometers and particle accelerators) and virtual field trips to exotic locations such as the ocean floor or the surface of Venus;

Education and training markets are fragmented and difficult to reach since the advantages of the new technology require major changes in learning strategies and pedagogic techniques and therefore extensive training for teachers and instructional staff. This program will support research to accelerate development of what promises to be a large, and vigorous commercial enterprise supplying America's growing demand for learning.

Federal investment priorities include 5 main areas. *Demonstrations that test advanced concepts in learning technologies* will expand the state of the art in curriculum design, learner-centered and exploratory instructional strategies, and use of advanced software design. *Fundamental research on the way people learn* will focus on the way new technologies can be used to enhance learning. *Development of learning tools* will ensure availability of tools for synthetic learning environments, collaborative problem solving environments, software interfaces, instructional software development tools, interactive instructional systems, intelligent learning associates, and tools for searching multimedia data bases and digital libraries. *Development of assessment tools* will undoubtedly change our expectations about learning and about the kinds of skills that can be measured. *Digitization of federal resources* will provide key resources for commercial developers interested in marketing interactive systems to both education and entertainment markets.

While virtually all other sectors of the economy have been transformed by technological innovation and accompanying structural reorganization in the 20th century, methods used for education and training look much like they have for generations. By accelerating the development and adoption of information technologies in education and training, we hope to ensure all Americans access — anytime and anyplace — to quality education and training tailored to their needs.

Our primary and secondary school and job training programs are in serious need of repair and modernization, but our system of higher education and post-baccalaureate training leads the world in quality and access. Even as

'We hope to ensure all Americans access to quality education and training.'

"Our Nation leads the world in information technology."

we respond to the fiscal realities of the times, we must nourish the "seed corn" of our future. Thus we must maintain our commitment to training the next generation of scientific leaders and continue to forge partnerships to support this effort.

Information technology. Our Nation leads the world in developing and applying information technology that can revolutionize the way we live, learn, and work. Because of the strategic value of these technologies and their potential for fostering economic growth, nations around the globe are investing heavily in the development and deployment of computer systems and telecommunications networks. Our vision for federal investment in information technology is to accelerate the evolution of existing technology and to nurture innovation that will enable its universal, accessible, and affordable application to enhance America's economic and national security in the 21st century.

Geographic distance, time to accomplish tasks, separation of people from resources, and outdated organizational structures have traditionally been barriers to progress. Information technology has an unprecedented ability to remove these barriers. Never before has there been an opportunity on such a grand scale to harness such a diverse range of technologies and to integrate them into a truly global interconnected information infrastructure. This emerging system will benefit not only all Americans, but people everywhere.

The federal government supports:

- Long-term scientific and technical research in information and communications;
- University research that trains our country's future leaders in information and communications science and engineering; and
- Information and communications research and development essential to agency missions and national goals.

The Administration's information research is concentrated on 6 Strategic Focus Areas:

- *Global-scale information infrastructure technologies,* including advanced application building blocks and widely accessible information services, available to applications developers and users, that provide a network interface for constructing large-scale integrated and distributed applications.
- *Scalable systems technologies* that will broaden the deployment of all information and communications technologies by allowing both "high-performance" and "low-end" applications to operate in an integrated, seamless fashion.
- *High confidence systems* that will provide the availability, reliability, integrity, confidentiality, and privacy needed by the increasingly diverse users of our Nation's emerging information infrastructure.
- *Virtual environments* that will allow diverse groups of people to interact in real time and in increasingly realistic ways over large distances. Virtual environments in science and telemedicine will continue to play a transforming

role in scientific experimentation, and an increasingly important role in education and training.

- *User-centered interfaces and tools* that are "user-friendly" and easy to use regardless of physical ability, education, and cultural background and that will allow end users to easily tailor and develop applications and services to meet individual needs.
- *Human resources and education tools and services* that will establish a foundation for new educational technologies necessary to allow a diverse workforce and student population to participate in the 21st century information revolution.

Specific research and development activities include research in components, communications, computing systems, support software and tools, intelligent systems, information management, and advanced prototype applications. The ultimate customers for information and communications research and development are the users of tomorrow's systems. We have identified three broad classes of user-driven applications which focus on removing barriers to progress:

- High performance applications for science and engineering — pushing the envelope of computational capabilities and enabling new discoveries in science and engineering;
- High confidence applications for dynamic enterprises — improving integration, privacy, security, and reliability of information flows within and across enterprises.
- High capability applications for the individual — empowering individuals with universal, easy-to-use access information, and providing customization and support of their information space.

ADVANCED DISTRIBUTED SIMULATION ENHANCES MILITARY READINESS

The constant tension between safety and realism in the military training environment can be eased by simulation. In the early days of simulation, for example, the Link trainer taught basic airmanship without ever leaving the ground. More recently, simulation technology has become a central component of the training regimen of U.S. military forces.

Today a quiet revolution in simulation is underway. A key technology links discrete simulations across wideband communications channels, making possible interactive operations among people and systems at widely dispersed geographical locations. Called Advanced Distributed Simulation (ADS), this technology offers the possibility of integrating manned simulators, weapons systems from instrumented ranges, and computer generated simulations into a "synthetic battlespace" that provides a more realistic, tactically relevant, and comprehensive training environment than ever before.

In late 1994, the Advanced Research Projects Agency (ARPA), in conjunction with the Services and the Defense Modeling and Simulation Office, demonstrated the value of ADS in an actual NATO exercise, Atlantic Resolve 94. Up to twenty-one hundred entities from sixteen sites on two continents were linked. It was the first time that the services successfully linked simulators with live ships, tanks, and aircraft in a wartime scenario. So transparent was the integration that operational commanders in the exercise could not detect the difference between live and simulated forces. ADS will have a vital role in preparing our forces for warfare in the future.

> *Science and technology support our national security strategy.*

National Security. Science and technology support the Administration's national security strategy in 3 important ways.

- Advances in science and technology ensure the technological superiority essential to maintaining our unparalleled military capabilities.
- A vibrant high technology industrial sector enhances our national economic strength while providing the technological base for advanced military capabilities.
- Technology is central to our efforts to: prevent and counter the proliferation of weapons of mass destruction and the means of their delivery; verify and monitor existing and prospective arms control agreements; and ensure the safety and reliability of our reduced nuclear weapons stockpile.

Maintaining a strong military. During the Cold War, technological superiority allowed us to counter a numerically superior adversary. Now, although the threat has changed, we remain committed to technological superiority because it allows us to field the strongest military at the lowest cost—both economic and human.

A strong domestic science base supporting a robust national security science and technology program is critical to preserving technological advantage. But racing for the lead in all areas is not a sufficient investment criteria. Our strategy is to apply resources broadly at the basic research level and make further investment decisions as emerging technologies reveal the most promising payoff areas. We are giving priority to programs that improve our warfighting capabilities, such as applications of information technology; to programs that address affordability, such as manufacturing and producibility technologies; and to technologies for new missions, such as counterproliferation, that are growing in importance.

Strengthening the industrial base. The long-term sustainment of our industrial capability is crucial to maintaining technological superiority. What we had during the Cold War — a defense industry that was distinct from civilian industry — will not serve us well in the future. Our strategy is to break down the barriers between the defense and commercial industrial sectors so that we have access to the best of both for our military applications. Many of the technologies we need for advanced military capabilities are available in the commercial sector, and in some cases they are more advanced and cost less. We are working to enhance our relationship with private industry through partnerships that enable us to capture those commercial technologies that offer the greatest military application. The long-term payoff will be better military capabilities at lower cost, and a strengthened economy.

Technology to control weapons of mass destruction. Science and technology play key parts in our national strategy to stem the proliferation of weapons of mass destruction (WMD) and their means of delivery. Arms control is an integral component of our strategy to promote U.S. national security. Verification and monitoring of compliance with arms control agreements is made possible by unique abilities provided by American basic and applied sci-

ence in fields as diverse as chemistry, optics, and solid state physics. Technology also supports our policy goals of discouraging accumulation of weapons usable fissile materials, strengthening controls on those materials, and reducing global stocks. Science and technology also make vital contributions to the safe stewardship of our own nuclear weapons. With the current moratorium on underground nuclear testing and the Administration's commitment to a verifiable Comprehensive Test Ban Treaty, we have structured a science-based stockpile stewardship program that will apply scientific understanding, predictive capability experiments, and simulation to ensure the safety, security, and reliability of our enduring nuclear stockpile.

International science and technology cooperation. We can contribute to important U.S. interests through mutually beneficial international cooperation. International science and technology cooperation encourages development of free-market economies, creates and expands markets for U.S. goods and services, and helps to build peaceful relations. Science and technology cooperation also helps build stability by addressing global stresses, such as overpopulation, poverty, migration, environmental degradation, resource depletion, and infectious disease.

Expanding international markets. Scientific and technological cooperation with other countries, particularly the emerging markets in which three-fourths of the growth in world trade is likely to take place, also helps to foster the development of export opportuni-

COOPERATING TO CONTROL BOMB MATERIALS

The Cold War may be over, but thousands of weapons and hundreds of tons of plutonium and highly-enriched uranium (HEU) must still be effectively controlled. Recent seizures of smuggled plutonium and HEU—the essential ingredients of nuclear weapons—demonstrate the urgency of this global problem. We have responded with a comprehensive, four-part plan that lies at the core of our efforts to stop nuclear proliferation and ensure that nuclear arms reductions are truly irreversible:

- *Securing nuclear materials.* At many sites in several countries, new fences are being built, cameras and motion detectors are being installed, and safeguards experts are being trained. This effort scored a dramatic success with Project Sapphire, which moved half a ton of HEU from Kazakhstan to secure storage in the United States.
- *Building confidence through openness.* At their September 1994 summit, President Clinton and Russian President Yeltsin agreed that for the first time, our two countries would tell each other how many weapons they have, and how much plutonium and HEU. We followed up with a sweeping openness proposal designed to confirm the dismantlement of thousands of nuclear weapons and the safe and secure storage of hundreds of tons of weapons-usable material.
- *Halting production.* In June 1994, Vice President Gore and Russian Prime Minister Chernomyrdin signed an agreement banning production of plutonium for weapons, and requiring Russia to shut down its production reactors by the year 2000.
- *Long-term disposition.* We will transform these materials into forms that no longer pose an urgent proliferation threat, so that they will not have to be guarded forever. We have purchased 500 tons of Russian HEU, blended to low-enriched reactor fuel that cannot be used for weapons for sale on the commercial market, and have initiated a U.S.-Russian study of what should be done with excess weapons plutonium.

"Science and technology cooperation contributes to sustainable development."

ties for American goods and services. Important fields for cooperation include information infrastructure, environmental technologies, and standards. Our cooperation, while building commercial opportunities, also builds the relationships that form the basis for dealing with issues such as nuclear nonproliferation and intellectual property protection. Our extensive cooperation with Russia provides an example of building mutually beneficial technology cooperation while assisting in the establishment of market and democratic institutions.

Promoting regional and global stability. The end of the Cold War fundamentally changed America's security imperatives. Proliferation of weapons of mass destruction poses a continuing threat, as do infectious disease, large-scale environmental degradation, depletion of soils and other resources, and other stresses that undermine economic progress and political stability in many countries and regions. Science and technology cooperation can assist in ameliorating such stresses, thus contributing to sustainable development. For example, preserving global biological diversity resources is important for food and health goals in all countries, including our own. Monitoring and containing emerging and reemerging infectious diseases is a common challenge. Through science and technology cooperation, nations and regions can work together to meet such challenges. The establishment this year of the Interamerican Institute for Global Change Research is an excellent example of such cooperation.

World leadership and cooperation in science, mathematics, and engineering. Since the end of World War II, the United States has been an unquestioned world leader in science. We have made distinct advances in the exploration of the physical world at the extremes of distances and scale: the repaired Hubble Space Telescope reveals the continuing evolution of the universe, while the world's highest energy particle collider, the Tevatron at the Fermi National Accelerator Laboratory, enabled the first direct observation of the elusive "top" quark.

We reaped great rewards from this position of leadership. From intriguing questions about the magnetic resonance properties of individual atoms, chemists developed tools for analyzing the chemical structure of a material. That led, in combination with fundamental advances in electronics and mathematics, to such forefront medical diagnostic tools as magnetic resonance imaging and positron-electron tomography. From basic research on genetics, came the forensic applications of DNA fingerprinting. Relying on the tools of molecular biology, the polymerase chain reaction and recombinant DNA techniques, new statistical methods, and the application theories of population genetics, DNA fingerprinting is a means to identify DNA from crime scenes. These are but two examples of the consistently high return the federal investment in fundamental science yields for the American public.

As a nation, however, we find it increasingly difficult to underwrite research at the forefront in all areas of science. As research facilities grow more sophisticated and expensive, in some cases our best option is to internationalize the construction and operation of the required research tools. As an example, we are actively discussing greater U.S. participation in the planned Large Hadron Collider in Geneva, which will be the world's highest energy collider.

World leadership in fundamental science must, in the near term, be accomplished for the most part by realigning the existing investment. We have strengthened the federal investment in fundamental science by emphasizing research conducted in academic institutions and merit reviewed research. When research is conducted in an educational setting — universities, medical schools, and other educational institutions — it has a multiplier effect. New knowledge is created, and new scientists and engineers are trained. Experience has also taught us that merit reviewed research— research where scientific peers evaluate competing proposals — improves the quality of the scientific enterprise.

The Administration is committed to a federal-university partnership that enhances the continued health of our major research institutions. This includes continuing to maintain the Nation's research infrastructure. The federal government currently participates by financing a share of this infrastructure through direct grants to universities for construction, and reimbursement to universities for research costs associated with renovation, con-

THE FOOTPRINTS OF THE QUARK

In April 1994 the Department of Energy's Fermi National Accelerator Laboratory announced the first experimental evidence for the subatomic particle called the top quark. The search had not been easy. Experiments, indeed entire particle accelerators, in Europe, the U.S. and Japan, had come and gone, and still physicists had not found the top quark. Yet far from concluding that they were chasing a moonbeam, most physicists remained confident of the existence of this fundamental particle of matter. They were so certain of their quarry because of their confidence in the model they had built to describe the way the universe works. The model describes the structure of matter at its ultimate level, inside the protons and neutrons of the atomic nucleus. Finding direct evidence for this last undiscovered quark would provide critical support for this model, a theory known as the Standard Model of Particle Interactions, or the Standard Model for short.

The top quark eluded discovery for so long because of its large mass in comparison to other subatomic particles—more than 30 times greater than the next-heaviest quark, the bottom. Of all the particle accelerators now operating anywhere on earth, only Fermilab's Tevatron particle accelerator has enough energy to produce top quarks in collisions between protons and antiprotons, their antimatter counterparts. When proton and antiproton collide at nearly the speed of light, they create a tiny fireball of pure energy. Some of the energy turns into matter, according to Einstein's famous equation E = mc2, yielding sprays of exotic particles. Huge particle detectors have the job of sorting through trillions of such collisions to find the half-dozen that show evidence for the top quark.

Why the top quark is so heavy remains a mystery that may, in fact, open a new frontier of particle physics. No one expected to find the tiny particle weighs more than an entire atom of gold. Because the top quark is so massive, it may shed light on the origin of mass, one of the most urgent unanswered questions confronting physics today.

MOUSE MODEL LEADS TO DISCOVERY OF OBESITY GENE

In perhaps the greatest discovery in obesity research to date, researchers have isolated a defective mouse gene that results in profound obesity and non-insulin-dependent diabetes mellitus. The scientists located the gene by studying a strain of mouse that can weigh up to five times more than normal. Their studies suggest a mechanism for how the obesity gene controls the amount of fat deposition. The normal mouse gene appears to be switched on in fat tissue, where it generates a protein that is secreted into the bloodstream and, once it reaches the appetite-controlling area of the brain, acts to regulate food intake. A defective obesity gene may produce little or no protein, and so the brain would not receive the proper message about the status of body fat stores, and appetite control would be lost. Investigators used their knowledge of the mouse gene to pinpoint a nearly identical obesity gene in human DNA. Because of the close similarity between the human and mouse genes, it is likely that they perform similar functions. Scientists are now investigating whether the gene is mutated in obese humans. It is likely that human obesity will be much more complicated than obesity in the mouse, possibly involving multiple genes and proteins. Nonetheless, this landmark research may eventually lead to more effective medical therapies for weight problems, and to testing for genetic predisposition for obesity early in life, when dietary modification might help prevent obesity and reduce the prevalence and ultimately the cost of many chronic obesity-related diseases, including non-insulin-dependent diabetes.

struction, operation, and maintenance of research facilities. The basis for the calculation of the reimbursement of these costs has been a matter of public misunderstanding, congressional inquiry, and continuing friction between universities and federal agencies. In the spirit of the National Performance Review, the Administration, working in concert with the private sector, announced several important changes in how government pays for research and development. These changes will simplify administrative and accounting procedures; promote predictability, stability, equity and consistency in federal payments for research; and make the federal investment in research more understandable to Congress and the public. In the long run, the changes will also generate cost savings since the new system will be more efficient and uniform. The savings will be invested in high priority research and development.

Space and Aeronautics. The Administration recognizes the special role that space and aeronautics technologies play in advancing U.S. economic, national security, and foreign policy interests. The international space station is perhaps the Administration's most visible commitment to U.S. leadership in aerospace technology. The space station has been redesigned to reduce its cost, to improve its performance and safety, to accelerate its schedule, and to make it more relevant to today's economic and political climate. The inclusion of Russia as a full partner in the station program (which also includes Japan, Canada, and the Europeans) reflects not only the benefits we believe can be derived from the incorporation of Russian space technology, but also the importance of broad international cooperation in the pursuit of progress in science and technology. We expect that research on board the space station will provide important new scientific and technical insights and will lay the groundwork for mankind's next steps into space.

We are also committed to making investments that will allow industry to dramatically reduce the cost of space transportation. In August 1994, NASA began development of a new generation of launch vehicle technologies that could eventually replace the expensive Space Shuttle. Similarly, the Department of Defense has developed a strategy for evolving the existing expendable launch vehicles into a fleet of vehicles that is significantly more cost effective. These government actions, combined with the energy and creativity of the private sector, not only holds out the possibility for much less expensive access to space for science, exploration, and national security, but lays the foundation for assuring U.S. industry's position as a leader in the commercial space launch market.

'We maintain our commitment to using space technology for scientific research.'

We also maintain our commitment to using space technology for scientific research. Through NASA's Mission to Planet Earth — a key component of the U.S. Global Change Research Program — we will gain new insights into the fundamental processes of our planet. These insights can have a positive effect on our economy and our environment as we benefit from new knowledge of weather prediction, agriculture, disaster prediction, and other complex processes.

Besides exploring our own planet, NASA is planning a new generation of small, low-cost spacecraft that will provide new opportunities for exploration and discovery elsewhere in the solar system. These new programs, combined with our sustained commitment to important facilities such as the Hubble Space Telescope, will expand our already significant efforts to understand the nature of the universe in which we live.

The U.S. aeronautics industry has benefited greatly from its strong research and technology partnership with the federal government. U.S. firms lead the world in the manufacture of aircraft, engines, avionics, and air transportation system equipment. This leadership role has translated into hundreds of thousands of high-quality jobs and a significant contribution to our balance of trade — more than $28 billion in 1993 on exports of $40 billion.

The Administration's continued support for aeronautics technologies will help to ensure that U.S. industry remains a world leader in the development of new aircraft and engines, a tenuous position given other governments' support for their national industries. We are developing a validated technology base which will enable the commercial development of a new generation of safe subsonic and high-speed commercial transport aircraft that far surpass today's aircraft in affordability, efficiency, and environmental compatibility.

Federal research and development is also playing an important role in helping to ensure the development and implementation of a new, efficient, safe, and affordable global air transportation system. In particular, new technologies such as the Global Positioning Systems (GPS), a space-based positioning, navigation, and time distribution system originally designed to meet world-wide military needs for precise global navigation and positioning, may result in billions of dollars in annual savings to the airlines and a significant global market for new U.S. products and services. GPS has found many

"For the first time, the United States has a comprehensive, coordinated, Cabinet level body devoted to the federal research and development enterprise."

unexpected civil and commercial applications, from surveying and mapping to commercial vehicle fleet management and air traffic control. More and more people are experiencing first-hand the use of GPS in personal automobile navigation, routing, and fleet management. In the aeronautics arena, the Federal Aviation Administration (FAA) has defined the technical standards for GPS receivers to be used in civilian aviation, and a DOD-DOT team is working to identify and resolve issues related to augmentation of the current GPS system for use in air traffic management.

Finally, federal research and development will help to ensure the long-term environmental compatibility of the aviation system. New technologies hold the promise of even greater increases in energy efficiency and further significant reductions in noise and potentially harmful chemical emissions.

Government Reforms

Over the past two years, the Administration has been working to improve the federal research and development enterprise in many ways. We recognized that, in order to confront today's challenges, significant changes were needed in the way we plan and fund federal research and development. The traditional single agency, single disciplinary approach to problem solving no longer adequately addresses the complex issues of the science and technology environment. Multi-dimensional problems can only be addressed by bringing together natural and social scientists, economists, engineers, and policy-makers. For too long, science has been largely decoupled from informing public policy choices, such as regulatory decisions.

The National Performance Review recommended creating a National Science and Technology Council (NSTC) to coordinate and implement science and technology policy. Created by Executive Order in November 1993 (Appendix 1), the NSTC provides an example of how those seeking to reinvent Government can work with existing resources to more efficiently and effectively serve the needs of the American people. For the first time, the United States has a comprehensive, coordinated, Cabinet level body devoted to the federal research and development enterprise. The principal purposes of the NSTC are to:

- identify national goals that require concerted research and development efforts;
- identify the high priority research and development needed to meet those goals; and
- coordinate research and development government wide to make sure that adequate attention is given to high priority areas, and to avoid wasteful duplication.

The NSTC is a virtual department — a coalition of agencies that coordinate their efforts, divide tasks, and share resources to advance science and technology. This forum for direct communication between agencies cuts through bureaucracy and encourages the identification of common goals and objectives.

Committees of the NSTC developed principles and priorities that gave direction to the research and development budget development process for FY 1996. They coordinated research and development budget recommendations for accomplishing national objectives with the focus on broad national goals. In coming years, the Administration will work toward refining this process of identifying priorities and providing guidance to the agencies to ensure that, in a time of limited funding, the highest priorities of the nation will be advanced.

The 9 Committees of the NSTC span the entire federal research and development enterprise (Appendix 2). They developed strategic implementation plans that further articulate the goals and objectives of specific science and technology areas. This strategic planning initiative required the agencies to review major science and technology initiatives in terms of appropriate agency roles, milestones, performance measures, resources, private sector input, and international issues. We will use these plans to gauge progress. Though changing national needs and the success or failure of different research avenues may require periodic reassessment of the goals now set, the framework that has been created is flexible enough to easily reorient to new opportunities and new priorities.

The NSTC also provides a means for interagency development and review of major science and technology policy decisions. NSTC Presidential Decision Directives are one mechanism used to implement major policy decisions. The NSTC review process ensures that all the agencies impacted by a decision have the opportunity to provide input.

RISK ANALYSIS: LINKING SCIENCE AND ENVIRONMENTAL POLICYMAKING

Factors within and outside our control—what we eat and drink; the air we breathe—influence the risks we face in our daily activities. Informed decisions, at the personal or community level, can reduce risks at considerably less expense than the cost of response.

Policies to address risks to public health, safety, and the environment must be fair, effective, and affordable. The Administration has taken several steps to advance risk analysis, a key linkage between science and policy, including establishing the following priorities for investigation:

- *Uncertainty analyses and risk characterization:* research on methods for improvement of risk characterization and transfer of scientific information about risks, and the uncertainties in the information, to decision makers.
- *Criteria and indicators for ecosystem health:* research to identify criteria and indicators for risks to ecological health and sustainability.
- *Human and ecological exposure:* research on chemical, physical, and biological stressors, particularly for mixtures, multiple and/or cumulative exposures, and alternative pathways of exposure.
- *Mechanisms of disease & ecological impacts:* research to identify and predict the magnitudes of new ecological risks and noncancer human health effects and to understand better the biological effects of carcinogens at very low doses.

The Administration is working within and across agencies to improve the methods by which risks are evaluated and the ways in which the resulting information is integrated with economic, social, and other considerations in making decisions that will ensure the protection of public health, safety, and the environment.

'The NSTC process has been useful for improving the efficiency of federal research and development programs.'

The NSTC process led to a decision to converge the polar orbiting environmental satellite systems of the Departments of Defense and Commerce. This decision should save the American taxpayer several hundred million dollars by the turn of the century. Another Presidential Decision issued in 1994 directed continuation of the Landsat remote sensing satellite program and restructured federal agency responsibilities for acquiring and operating the next satellite (Landsat-7). This decision insures the continuity and availability of the Landsat remote sensing capability which is used for civil, commercial and national security purposes. A third NSTC Presidential Decision articulated the new national space transportation policy and established clear roles and responsibilities for the principal agencies.

The NSTC process has been useful for improving the efficiency of federal research and development programs. As an example, a 1994 NSTC Presidential Review Directive ordered an interagency review of the federal government's 3 largest laboratory systems — the Department of Defense, the Department of Energy, and the National Aeronautics and Space Administration. The NSTC is integrating the laboratory system reviews being conducted by the individual agencies and will produce a report with options and recommendation concerning the role and future of the 3 laboratory systems. Also in 1994, 4 agencies signed a memorandum of understanding to establish, jointly fund, and oversee a data bank containing atomic coordinates and related structural information for biological macromolecules.

The NSTC is committed to outreach and collaboration with the private sector and the public to ensure that federal science and technology policies reflect the full spectrum of the Nation's needs. A primary means of obtaining input from outside the federal government is through the sponsorship of forums and workshops designed to bring together a variety of stakeholders in a given area. The NSTC has convened and is planning for several forums to engage a broad cross-section of industry and academic leaders in the debate on critical science and technology issues, including:

- Forum on Science in the National Interest (February 1994)
- Forum on Environmental Research and Development (March 1994)
- Forum on Health, Safety, and Food (November 1994)
- White House Conference on Environmental Technologies (December 1994)
- Forum on Future Directions in Transportation Research and Development (March 1995)
- Forum on Science, Engineering, and Technology in Enhancing Global Stability (March 1995)

In 1995 and beyond, the NSTC will continue to sponsor and co-sponsor a variety of events to ensure that the goals and priorities of the Administration reflect the needs of the public. It is essential that resources be directed to those areas of highest priority, and it is only through continued communication with stakeholders that we can ensure that those priorities are identified.

Another very effective means of obtaining input from outside the federal sector is through consultation with the President's Committee of Advisors on Science and Technology (PCAST). (Appendix 3) The goal in creating the PCAST was to ensure, through the involvement of the private sector, that federal science and technology policies are reflective of our Nation's needs. The PCAST consists of a group of 18 highly qualified individuals from industry, education and research institutions. (Appendix 4) These individuals are an extremely diverse and talented group and provide the NSTC with an invaluable resource pool for use in developing successful science and technology policies.

America's welfare hinges as never before on the way we manage the opportunities and the hazards of new concepts in science and technology. We are in the middle of a science and technology revolution. But America's federal science and technology enterprise has changed to match the needs of a dynamic economy.

Through the NSTC we have reorganized the federal science and technology enterprise without the creation of a large, new bureaucracy. We have produced a research and development budget that, within the spending limits established by the new covenant with America, ensures a better world for our children and their children. We have integrated federal science and technology programs with efforts in the private sector and internationally in order to maintain a strong, vibrant, sustainable economy.

'The federal science and technology enterprise has changed to match the needs of a dynamic economy.'

APPENDIX 1

Executive Order 12881 of November 23, 1993 Establishment of the National Science and Technology Council

By the authority vested in me as President of the United States by the Constitution and the laws of the United States of America, including section 301 of title 3, United States Code, it is hereby ordered as follows:

Section 1. *Establishment.* There is established the National Science and Technology Council ("the Council").

Sec. 2. *Membership.* The Council shall comprise the:

(a) President, who shall serve as Chairman of the Council;
(b) Vice President;
(c) Secretary of Commerce;
(d) Secretary of Defense;
(e) Secretary of Energy;
(f) Secretary of Health and Human Services;
(g) Secretary of State;
(h) Secretary of the Interior;
* Secretary of Transportation;
* Secretary of Education;
* Secretary of Labor;
* Secretary of Agriculture;
(i) Administrator, National Aeronautics and Space Administration;
(j) Director, National Science Foundation;
(k) Director, Office of Management and Budget;
(l) Administrator, Environmental Protection Agency
(m) Assistant to the President for Science and Technology;
(n) National Security Adviser;
(o) Assistant to the President for Economic Policy;
(p) Assistant to the President for Domestic Policy;
* Chair, Council of Economic Advisors
* Director, Central Intelligence Agency
* Director, National Institutes of Health
* Director, Arms Control and Disarmament Agency
(q) Such other officials of executive departments and agencies as the President may, from time to time, designate.

Sec. 3. *Meetings of the Council.* The President, or upon his direction, the Assistant to the President for Science and Technology ("the Assistant"), may convene meetings of the Council. The President shall preside over the meetings of the Council, provided that in his absence the Vice President, and in his absence the Assistant, will preside.

Sec. 4. *Functions.*

(a) The principal functions of the Council are: (1) to coordinate the science and technology policy making process; (2) to ensure science and technology policy decisions and programs are consistent with the President's stated goals; (3) to help implement and integrate the President's science and technology policy agenda across the Federal government; (4) to ensure science and technology are considered in development and implementation of all Federal policies and programs; and (5) to further international cooperation in science and technology. The Assistant may take such actions, including drafting a Charter, as may be necessary or appropriate to implement such functions.

(b) All executive departments and agencies, whether or not represented on the Council, shall coordinate science and technology policy through the Council and shall share information on research and development budget requests with the Council.

(c) The Council shall develop for submission to the Director of the Office of Management and Budget recommendations on research and development budgets that reflect national goals. In addition, the Council shall provide advice to the Director of the Office of Management and Budget concerning the agencies' research and development budget sumissions.

(d) The Assistant will, when appropriate, work in conjunction with the Assistant to the President for Economic Policy, the Assistant to the President for Domestic Policy, the Director of the Office of Management and Budget, and the National Security Adviser.

Sec. 5. *Administration.*

(a) The Council will oversee the duties of the Federal Coordinating Council for Science, Engineering, and Technology, the National Space Council, and the National Critical Materials Council.

(b) The Council may function through established or ad hoc committees, task forces, or interagency groups.

(c) To the extent practicable and permitted by law, executive departments and agencies shall make resources, including, but not limited to, personnel, office support, and printing, available to the Council as requested by the Assistant.

(d) All executive departments and agencies shall cooperate with the Council and provide such assistance, information, and advice to the Council as the Council may request, to the extent permitted by law.

* Members designated by the President subsequent to issuing the Executive Order

APPENDIX 2

NATIONAL SCIENCE & TECHNOLOGY COUNCIL COMMITTEES

Committee on Health, Safety and Food R&D

Chair:	Dr. Philip Lee, Department of Health and Human Services
V/Chairs:	Dr. Floyd Horn, Department of Agriculture
	Dr. David Kessler, Food and Drug Administration
OSTP:	Dr. M.R.C. Greenwood, Associate Director for Science

Committee on Information and Communication R&D

Chair:	Dr. Anita Jones, Department of Defense
V/Chair:	Dr. Paul Young, National Science Foundation
OSTP:	Mr. Skip Johns, Associate Director for Technology

Committee on National Security

Chair:	Dr. John Deutch, Department of Defense
V/Chair:	Dr. Vic Reis, Department of Energy
OSTP:	Ms. Jane Wales, Associate Director for National Security and International Affairs

Committee on Civilian Industrial Technology R&D

Chair:	Dr. Mary Good, Department of Commerce
V/Chair:	Dr. Martha Krebs, Department of Energy
OSTP:	Mr. Skip Johns, Associate Director for Technology

Committee on Fundamental Science

Co-Chairs:	Dr. Neal Lane, National Science Foundation
	Dr. Harold Varmus, National Institutes of Health
OSTP:	Dr. M.R.C. Greenwood, Associate Director for Science

Committee on International Science, Engineering, and Technology R&D

Co-Chairs: Dr. Tim Wirth, Department of State
Ms. Carol Lancaster, Agency for International Development

V/Chairs: Ms. Sue Tierney, Department of Energy
Dr. Philip Lee, Department of Health and Human Services

OSTP: Ms. Jane Wales, Associate Director for National Security and Intentional Affairs

Committee on Environment and Natural Resources Research

Co-Chairs: Dr. James Baker, National Oceanic and Atmospheric Administration
Dr. Ronald Pullium, Department of the Interior

V/Chairs: Dr. Robert Huggett, Environmental Protection Agency
Dr. Christine Ervin, Department of Energy

OSTP: Dr. Robert Watson, Associate Director for Environment

Committee on Transportation R&D

Chair: Dr. Mortimer L. Downey, Department of Transportation

V/Chair: Dr. Wesley L. Harris, National Aeronautics and Space Administration

OSTP: Mr. Skip Johns, Associate Director for Technology

Committee on Education and Training R&D

Chair: Gov. Madeleine Kunin, Department of Education

V/Chairs: Mr. Tom Glynn, Department of Labor
Dr. Luther Williams, National Science Foundation

OSTP: Dr. Henry Kelly, Assistant Director for Technology

APPENDIX 3

Executive Order 12882 of November 23, 1993

President's Committee of Advisors on Science and Technology

By the authority vested in me as President by the Constitution and laws of the United States of America, including section 301 of title 3, United States Code, and in order to establish an advisory committee on science and technology, it is hereby ordered as follows:

Section 1. *Establishment.* There is established the President's Committee of Advisors on Science and Technology ("PCAST"). PCAST shall be composed of not more than 16 members, one of whom shall be the Assistant to the President for Science and Technology, and 15 of whom shall be distinguished individuals from the nonfederal sector appointed by the President. The nonfederal sector members shall be representative of the diverse perspectives and expertise in this Nation's investments in science and technology. The Assistant to the President for Science and Technology shall co-chair PCAST with a nonfederal sector member selected by the President.

Section 2. *Functions.*

(a) The PCAST shall advise the President, through the Assistant, on matters involving science and technology.

(b) In the performance of its advisory duties, PCAST shall assist the National Science and Technology Council ("Council") in securing private sector involvement in its activities.

Section 3. *Administration.*

(a) The heads of executive departments and agencies shall, to the extent permitted by law, provide PCAST such information with respect to scientific and technological matters as required for the purpose of carrying out its functions.

(b) In consultation with the Assistant to the President for Science and Technology, PCAST is authorized to convene ad hoc working groups to assist the Council.

(c) Members of PCAST shall serve without any compensation for their work on PCAST. However, members may be allowed travel expenses, including per diem in lieu of subsistence, as authorized by law for persons serving intermittently in the Government service (5 U.S.C. 5701-5707).

(d) Any expenses of PCAST shall be paid from the funds available for the expenses of the Office of Science and Technology Policy.

(e) The Office of Science and Technology Policy shall provide such administrative services as may be required.

Section 4. *General.*

(a) I have determined that the Committee shall be established in compliance with the Federal Advisory Committee Act, as amended (5 U.S.C. App.). Notwithstanding any other Executive Order, the functions of the President under the Federal Advisory Committee Act, as amended, except that of reporting to Congress, which are applicable to PCAST shall be performed by the Office of Science and Technology Policy in accordance with the guidelines and procedures established by the Administrator of General Services.

(b) PCAST shall terminate two years from the date of this order unless extended prior to that date.

(c) Executive Orders Nos. 12700, 12766, and Section 2 of Executive Order No. 12869 are hereby revoked.

APPENDIX 4

THE PRESIDENT'S COMMITTEE OF ADVISORS ON SCIENCE AND TECHNOLOGY

Chairs

John H. Gibbons
Assistant to the President for Science and Technology

John A. Young
Former President and CEO
Hewlett-Packard Co.

Members

Norman R. Augustine
Chairman and CEO
Martin Marietta Corporation

Francisco J. Ayala
Donald Bren Professor of Biological Sciences
Professor of Philosophy
University of California, Irvine

Murray Gell-Mann
Professor, Santa Fe Institute
R.A. Millikan Professor Emeritus of Theoretical Physics
California Institute of Technology

David A. Hamburg
President, Carnegie Corporation of New York

John P. Holdren
Class of 1935 Professor of Energy
University of California, Berkeley

Diana MacArthur
Chair and CEO
Dynamac Corporation

Shirley M. Malcom
Head, Directorate for Education and Human Resources Programs
American Association for the Advancement of Science

Mario J. Molina
Lee and Geraldine Martin Professor of Environmental Sciences
Massachusetts Institute of Technology

Peter H. Raven
Director, Missouri Botanical Garden
Engelmann Professor of Botany
Washington University in Saint Louis

Sally K. Ride
Director, California Space Institute
Professor of Physics
University of California, San Diego

Judith Rodin
President, University of Pennsylvania

Charles A. Sanders
Chairman, Glaxo Inc.

Phillip A. Sharp
Professor of Biology
Head, Department of Biology
Massachusetts Institute of Technology

David E. Shaw
CEO, D.E. Shaw and Co.

Charles M. Vest
President
Massachusetts Institute of Technology

Virginia V. Weldon
Senior Vice President for Public Policy
Monsanto Company

Lilian Shiao-Yen Wu
Member, Research Staff
Thomas J. Watson Research Center
IBM

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Subject: receive environment (to receive Environment releases)
Subject: send science-technology FAQ (Information re: White House Electronic Publication Service)
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Modem: set modem to n,8,1; terminal emulation to ANSI; call 703-321-8020
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NSTC Strategic Planning Documents March 1995
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